ABSTRACT OF THE DISCLOSURE

Bottom-up filling of fine Damascene trenches and vias in semiconductor chips is attained using a copper pyrophosphate electroplating bath with a single accelerating additive species present at low concentration (< 5 μM). This bath is much easier to control than the acid copper sulfate bath, which employs a complicated additive system involving a minimum of two organic additives and chloride ion (as well as significant additive breakdown products). Pyrophosphate copper deposits exhibit stable properties without annealing and are typically twice as hard as acid sulfate copper deposits, which facilitates chemical mechanical planarization. The mechanical properties and texture of the fine-grained pyrophosphate copper deposits are also much less substrate dependent, which minimizes the effects of variations and flaws in the barrier and seed layers. Attack of copper seed layers is minimized for the copper pyrophosphate bath, which operates in the pH 8 to 9 range. The resistivity of pyrophosphate and annealed acid sulfate copper deposits are substantially equivalent.